High-Performance Seals

Parco

Elastomer Selection Guide

Find the Right Elastomer for Your Application

Selecting seal materials can be an intimidating task. There are many types of elastomers and each is available in many different compounds. There are nine popular elastomers used in seals. This selection guide surveys popular elastomers intended for service at pressures up to 1,500 psi. Detailed information on compounds of each elastomer may be found in Parco’s material selection guides. If you believe your application may require a special compound not listed, please contact a Parco customer service representative.

Elastomer Selection Criteria

1. Temperature Capabilities

Elastomer performance becomes less predictable when a seal operates near the limits of its service temperature range. Consider the effects of temperature extremes when selecting an O-ring material.

At low temperatures:

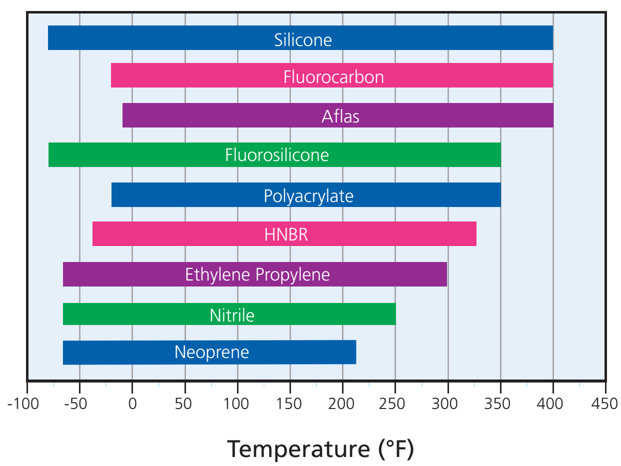
• Elastomers become harder and less flexible until, at the brittle point or glass transition, the seal may crack.

• Elastomers lose their rubber-like properties as the temperature drops. The TR-10 (temperature of 10% retraction) reflects the ability of an elastomer to retract, that is, behave like rubber, at low temperatures.

• Fluid may penetrate the seal and act as a plasticizer, effectively lowering the brittle point below the value observed in dry air. In such cases, the seal may operate effectively below its rated service temperature. This must be confirmed on a case-by-case basis.

Fig. 1:

Service Temperatures of Popular Elastomers



Compounding affects performance at both high and low temperatures. Not all compounds of a given elastomer have the same temperature range. The temperature limits in the chart span the range of the compounds of each elastomer.

Fig. 2: ***Fluid Compatibility by Elastomer***

Common Fluids	Nitrile	Fluorocarbon	EPDM	Silicone	Neoprene	Polyacrylate	Fluorosilicone	HNBR	Aflas®	Examples
ASTM D1418 Designation	NBR	FKM	EPDM	VMR	CR	ACM	FVMR	HNBR	FEPM	
Acids, dilute	Minor-to-moderate effect	Recommended	Recommended	Not recommended	Minor-to-moderate effect	Not recommended	Minor-to-moderate effect	Recommended	Recommended	Hydrochloric acid
Alcohols	Recommended	Moderate-to-severe effect	Recommended	Recommended	Recommended	Not recommended	Recommended	Recommended	Recommended	Methanol, ethanol
Alkalis, dilute	Minor-to-moderate effect	Moderate-to-severe effect	Recommended	Moderate-to-severe effect	Recommended	Not recommended	Minor-to-moderate effect	Recommended	Recommended	Sodium hydroxide
Brake fluid, non-petroleum	Not recommended	Not recommended	Recommended	Moderate-to-severe effect	Minor-to-moderate effect	Not recommended	Not recommended	Not recommended	Recommended	Wagner 21B®, Dextron®
Fuel oil	Recommended	Recommended	Not recommended	Not recommended	Moderate-to-severe effect	Recommended	Recommended	Recommended	Minor-to-moderate effect	Diesel oils 1-6
Hydraulic oil, phosphate-ester	Not recommended	Not recommended	Recommended	Moderate-to-severe effect	Not recommended	Not recommended	Moderate-to-severe effect	Not recommended	Recommended	Skydrol 500®, Hyjet®
Hydrocarbons, aliphatic	Moderate-to-severe effect	Recommended	Not recommended	Moderate-to-severe effect	Moderate-to-severe effect	Not recommended	Recommended	Minor-to-moderate effect	Not recommended	Gasoline, kerosene
Hydrocarbons, aromatic	Not recommended	Recommended	Not recommended	Not recommended	Not recommended	Not recommended	Minor-to-moderate effect	Moderate-to-severe effect	Not recommended	Benzene, toluene
Ketones	Not recommended	Not recommended	Recommended	Not recommended	Moderate-to-severe effect	Not recommended	Not recommended	Not recommended	Not recommended	Acetone, MEK
Mineral oil	Recommended	Recommended	Not recommended	Minor-to-moderate effect	Minor-to-moderate effect	Recommended	Recommended	Recommended	Recommended	—
Solvents, chlorinated	Not recommended	Recommended	Not recommended	Not recommended	Not recommended	Not recommended	Minor-to-moderate effect	Moderate-to-severe effect	Not recommended	Trichloroethylene
Steam, to 300°F	Not recommended	Not recommended	Minor-to-moderate effect	Moderate-to-severe effect	Moderate-to-severe effect	Not recommended	Not recommended	Minor-to-moderate effect	Recommended	—
Water	Recommended	Recommended	Recommended	Recommended	Minor-to-moderate effect	Not recommended	Recommended	Recommended	Recommended	—

Legend: *Recommended* · *Minor-to-moderate effect (useful in some static applications only)* · *Moderate-to-severe effect* · *Not recommended*

• Changes in elastomers due to low temperature are physical, not chemical, and are generally reversible. However, if the geometry of the gland changes while the seal is cold, the seal may be too stiff to adapt to the new shape and may fail. Movement may damage the seal while it is cold and inflexible.

At high temperatures:

• As temperatures approach the upper service limit, elastomers often undergo irreversible chemical changes. The polymer backbone may break or adjacent polymer molecules may cross-link, causing seals to become more rigid, reducing their resistance to compression set.

• The rate of many chemical reactions doubles with each increase of 10°C (18°F). The relationship between reaction rate and temperature of these first-order reactions can be used as a rough guide in predicting the service life of a material. Figure 1 assumes a service life of 1,000 hours at the upper rated temperature. An increase in operating temperature of 18°F may to cut seal life in half. The added cost of a seal with a wider service range may be an excellent investment.

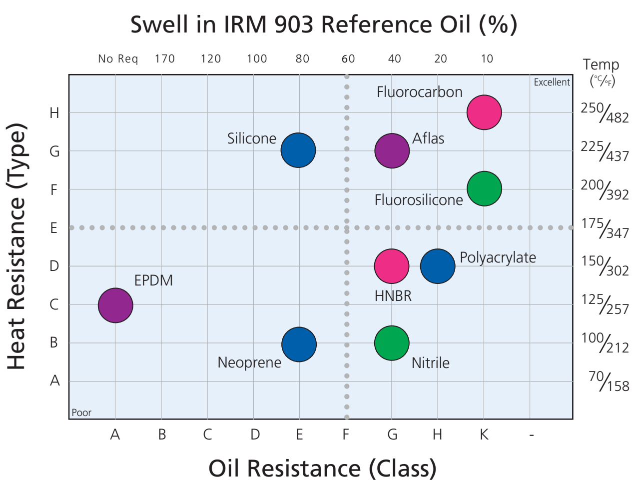
2. Fluid Compatibility

Figure 2 represents the fluid compatibility of the principal elastomers from left to right. Very high swell, rapid deterioration or complete breakdown of the seal can occur if the elastomer is not compatible with the fluid. Factors such as chemical concentration, system pressure, operating temperature, and seal design must be considered when specifying a seal. Parco recommends that you evaluate the selected seal in a functional test before using it in production.

Because so many applications involve hydrocarbons, a selection method based on the heat and oil resistance of the elastomers will encompass most users. In the ASTM D2000 system, elastomers are ranked by heat resistance (Type) and by oil resistance (Class). Employing the ASTM D2000 Type and Class system, Figure 3 displays the resistance of various elastomers to heat and to IRM 903, a common reference oil. However, compounds of a given elastomer can have different rankings for both Type and Class. The selection diagram on the last page also uses heat resistance and hydrocarbon compatibility as principal elastomer selection criteria.

Fig. 3:

ASTM D2000 Heat and Oil Resistance Designations



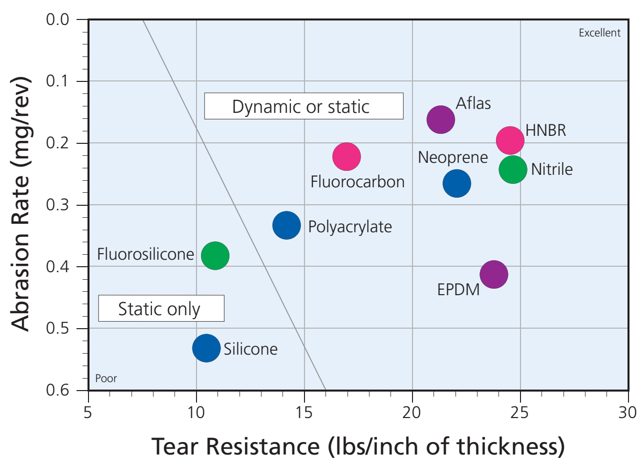
Elastomers fall into natural groups according to their heat and oil resistance. Those above the dotted line are recommended for elevated temperatures. Those to the right of the dotted line are preferred for use with hydrocarbons.

3. Abrasion and Tear Resistance

Abrasion-resistant seals are able to resist scraping or buffing. Abrasion resistance is generally a selection criteria for dynamic seals. Tear-resistant elastomers have superior ability to resist nicking, cutting, and tearing. Good tear resistance may be important in elastomer selection when the seal is to be installed by automated assembly equipment. Elastomers such as hydrogenated nitrile (HNBR) and Aflas are inherently abrasion resistant. Carboxylated nitrile (XNBR) offers significantly better abrasion resistance than standard nitrile. The abrasion and tear resistance of many elastomers can be enhanced by compounding with internal lubricants such as Teflon® or molybdenum disulfide.

Fig. 4:

Abrasion and Tear Resistance of Medium-Hardness Elastomers



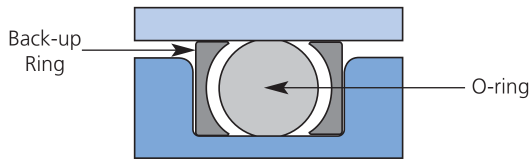
Silicone and fluorosilicone elastomers are used for static applications only. The elastomers lying to the right of the oblique line are suitable for either dynamic or static sealing. Abrasion and tear resistance vary with compound hardness.

4. Differential Pressure Resistance

Pressure applied evenly to both sides of a seal normally has no effect on sealing performance. When a pressure difference is anticipated, elastomer selection must also consider differential pressure resistance. High differential pressures will

Fig. 5:

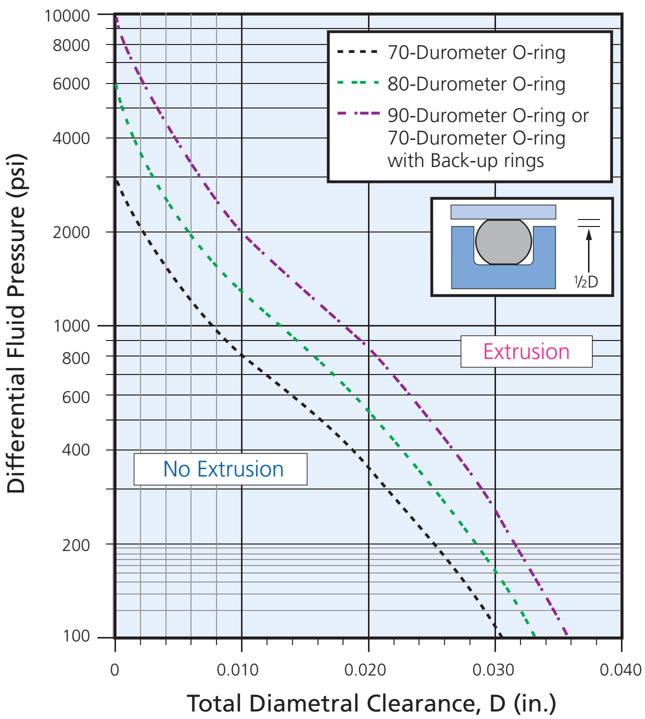
Back-up Rings



Parco back-up rings serve as anti-extrusion devices.

Fig. 6:

O-ring Extrusion from Differential Pressure



O-ring extrusion is rare at conditions lying to the left of a seal's performance line. For example, a 70-durometer seal with 0.005 inch gap (D=0.010) will seal to 800 psi but may extrude at higher differential pressures. For higher operating pressures, consult Parco's nitrile and fluorocarbon selection guides for high-pressure applications.

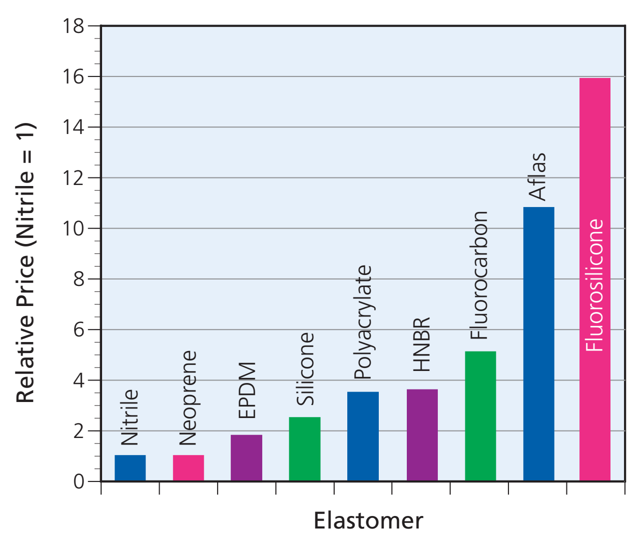
cause improperly specified O-rings to extrude, resulting in seal damage and eventual failure. Standard O-ring groove and gap dimensions cited in the MIL-G-5514 and AS4873 generally provide adequate sealing for differential pressures to 1,500 psi for all elastomers. Substantial improvement in extrusion resistance is attainable by 1) using harder O-rings, 2) decreasing the diametral clearance, or 3) using contoured hard rubber or plastic back-up rings. O-rings with high modulus and hardness are better able to resist extrusion. The higher the modulus of a material, the greater the force required to stretch it. Similarly, the harder the material, the greater its resistance to indentation.

5. Price

Assuming that several elastomers meet all other requirements for a given application, Figure 7 should aid in making an economical selection. The prices of seals of the same elastomer may vary widely due to differences in compounding and processing costs.

Fig. 7:

Relative Prices of Popular Elastomers

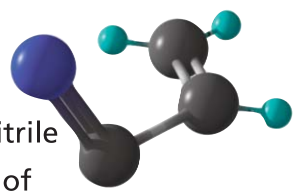


This chart shows the prices of Parco O-rings made of the most popular compound of each elastomer and is intended to provide a rough estimate of relative price. These prices are based on a comparison of 30 popular sizes of O-rings for each compound.

Popular Elastomers

The elastomers shown in the selection diagram (Figure 8) are the most popular used for O-rings. Variations in mechanical properties and seal performance exist among the compounds of a given elastomer, so price and suitability can vary accordingly.

Nitrile

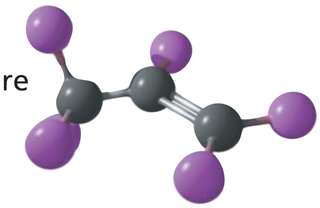


Nitrile is the standard to which all the other elastomers are compared. Nitrile compounds are copolymers of acrylonitrile and butadiene. Acrylonitrile provides resistance to petroleum-based fluids such as oils and fuels, while butadiene contributes low-temperature flexibility. Standard nitrile is also known as Buna N rubber. Because they are versatile and inexpensive, nitriles are the most popular industrial seal material.

Nitrile compounds provide excellent service with gasoline, crude oil, power steering fluid, hexane, toluene, water, water-based hydraulic fluids, and dilute bases such as sodium hydroxide. Because nitriles contain unsaturated carbon-carbon bonds in the base polymer, they are not suitable for exposure to ozone, sunlight, and weathering. More than 50% of sealing needs can be met using nitrile.

Individual nitrile compounds have service temperatures within the range from -65 to +250°F, including certain compounds formulated for lower temperatures. Parco's most popular nitrile compound is 4200-70.

Fluorocarbon



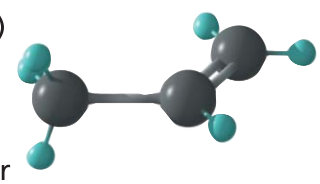
Fluorocarbon elastomers command a substantial share of the seal market. Fluorocarbons withstand a very broad spectrum of chemicals over a temperature range second only to that of silicone compounds.

Fluorocarbons are commonly rated for continuous service temperatures from -20 to +400°F, with intermittent exposures as high as 500°F.

In spite of their higher cost, fluorocarbons have replaced nitriles in many applications because of their superior resistance to compression set, high-temperature, and a wide range of chemicals.

Fluorocarbon compounds have service temperatures from -20 to +400°F. Parco's most popular fluorocarbon compound is 9009-75.

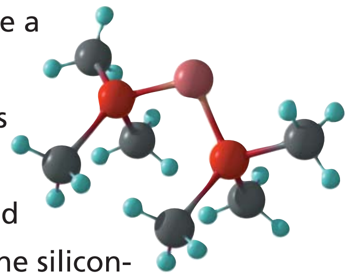
Ethylene-Propylene



Ethylene-Proplyene (EPDM) compounds are general-purpose materials with superior resistance to water and steam, alcohols, glycol engine coolants and similar polar fluids. EPDMs are frequently specified for Skydrol® and other phosphate-ester hydraulic fluids. EPDM seals offer excellent economy (Figure 7). They are not recommended for petroleum-based fluids and fuels.

Individual EPDM compounds have service temperatures within the range from -65 to +300°F, including certain compounds formulated for higher temperatures. Parco's most popular EPDM compounds are 5601-70 (sulfur-cured) and 5778-70 (peroxide-cured).

Silicone



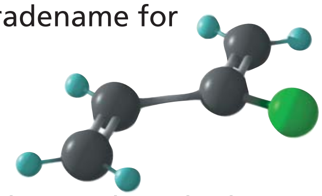
Silicone compounds have a backbone of alternating silicon and oxygen atoms rather than carbon linkages and are classified as inorganic materials. The silicon-oxygen bond is flexible at low temperatures and has better heat stability than the carbon-oxygen or carbon-carbon bonds of organic materials. Since the silicon-oxygen linkages are completely saturated, silicone elastomers are immune to many types of chemical attack that degrade organic elastomers with unsaturated carbon bonds. As a result, silicones possess excellent resistance to ozone, UV radiation, fungal and biological attack, and extreme temperatures. Silicones offer the widest service temperature of any elastomer.

Special silicone compounds remain flexible at temperatures as low as -175°F and can survive extreme heat to +600°F. Silicone seals are widely used in cryogenics and refrigeration, as electrical insulators, for transformer oils, and for dry heat exposure. They are not recommended for petroleum, ketones, or chlorinated solvents. They have high gas permeation rates and should be restricted to static service due to poor abrasion resistance.

Silicone compounds have service temperatures from -80 to +400°F. Parco's most popular silicone compound is 1200-70.

Neoprene™

Neoprene™ was the first commercially successful substitute for natural rubber in the United States.

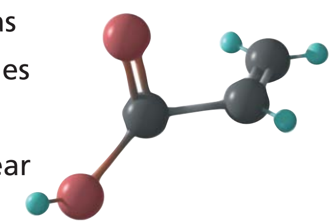


Neoprene™ is the Dupont tradename for chloroprene which is a monochlorinated butadiene polymer. The chlorine atom deactivates the adjoining carbon-carbon double bond, making it less susceptible to oxidation. Neoprene combines good resistance to weathering and petroleum-based lubricants, a wide temperature range, and exceptional economy.

Neoprenes have good abrasion and tear resistance and are suitable for use in heating, ventilating and air conditioning (HVAC) systems, refrigeration units, and numerous dynamic applications.

Individual neoprene compounds have service temperatures that range from -65 to +212°F, including certain compounds formulated for lower temperatures. Parco's most popular neoprene is 3110-70.

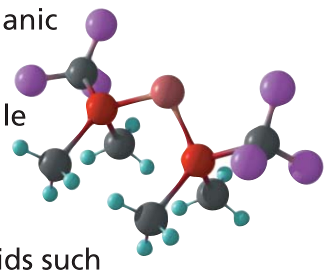
Polyacrylate



Polyacrylate, also known as polyacrylic rubber, combines excellent resistance to hydrocarbon fuels with near imperviousness to ozone, UV light, and other forms of weathering. Polyacrylates have an upper service temperature similar to fluorosilicones at a much lower cost. Applications include automatic transmission seals and power steering assembly seals used with Type A fluid.

Polyacrylate compounds have service temperatures from -20 to +350°F. Parco's most popular polyacrylate compound is 2990-70.

Fluorosilicone

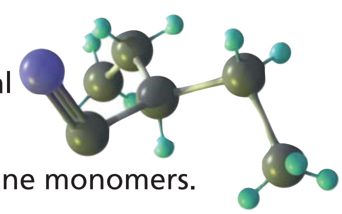


Fluorosilicone has an inorganic silicone-oxygen polymer backbone like silicone, while incorporating fluorine-rich polar groups that provide resistance to non-polar fluids such as hydrocarbon fuels. While silicones have ASTM D2000 ‘D’ or ‘E’ fuel resistance designations, fluorosilicones are classified as ‘K’, the highest level of fuel resistance (Figure 3). The heat resistance of the fluorosilicones is slightly below that of the silicones.

Fluorosilicones share the outstanding ozone, sunlight, and weathering resistance of the silicones. They find their widest use in aggressive military, aerospace, and automotive environments involving exposure to fuels over wide temperature ranges. They are not recommended for dynamic sealing due to poor abrasion resistance.

Fluorosilicone compounds have service temperatures from -80 to +350°F. Parco’s most popular fluorosilicone compound is 1933-70.

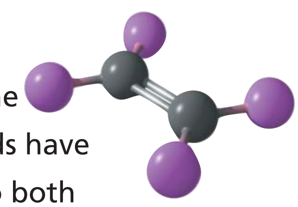
Hydrogenated Nitrile



Hydrogenated Nitrile (HNBR), like conventional nitrile, is made from acrylonitrile and butadiene monomers. After polymerization, a carbon-carbon double bond from the butadiene molecule is still present in the backbone of the nitrile polymer. These regions of unsaturation make the base polymer susceptible to uncontrolled cross-linking by heat, ozone, hydrogen sulfide, sour crude and other oxidizing agents. Degradation of ordinary nitriles includes increased hardness, loss in elongation and tensile strength, and surface cracking. This weakness in the nitrile polymer can be eliminated by saturating (reacting with hydrogen) the remaining carbon-carbon double bond. Hydrogenated nitriles significantly outperform conventional nitriles in resisting heat and sour crude oil.

HNBR compounds have a service range of -40 to +325°F. They are recommended when upgrading from nitriles or as an economical alternative to more expensive fluorocarbon elastomers. Parco’s most popular hydrogenated nitrile compound is 2269-70.

Aflas®

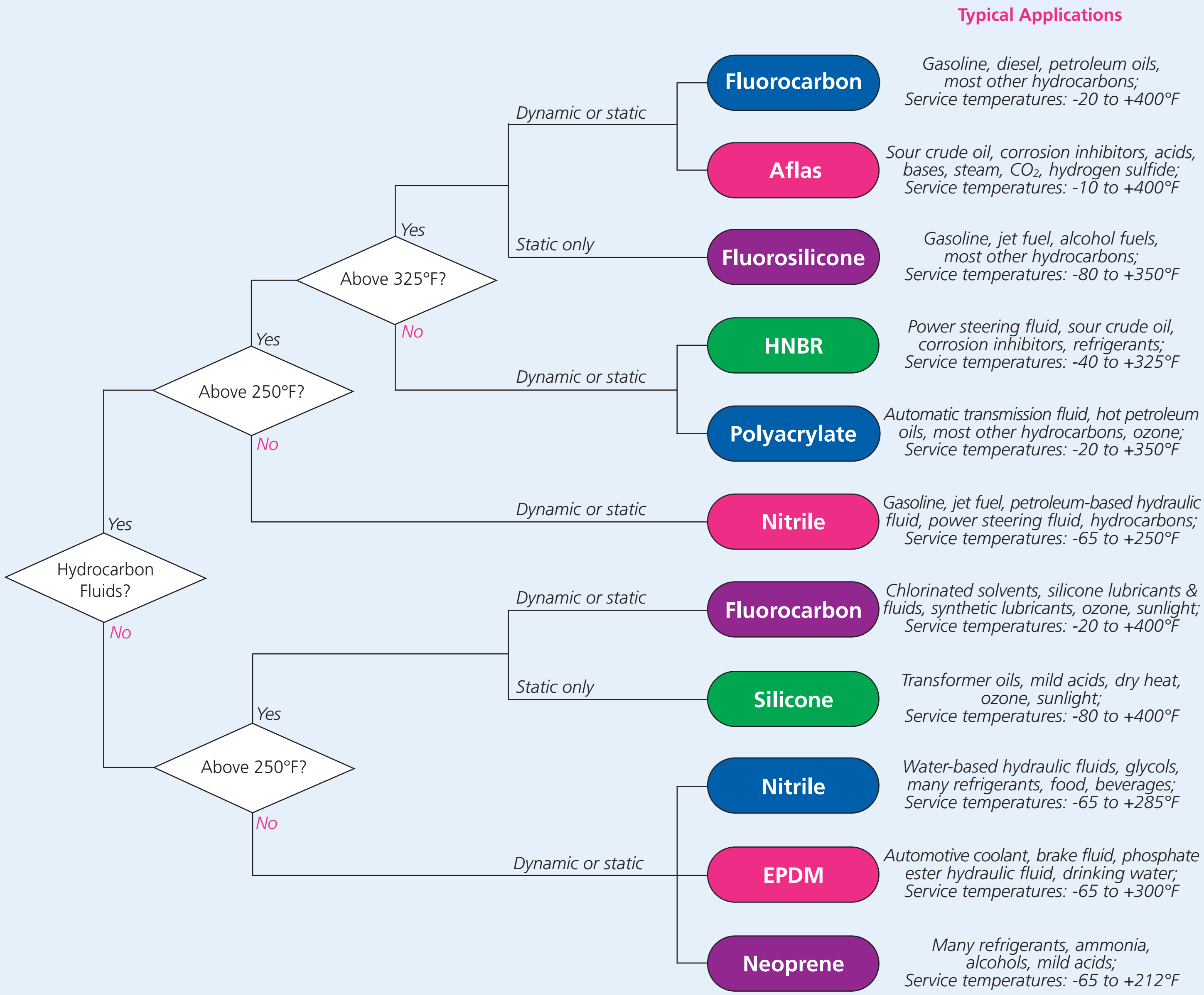


Aflas® is a trade name for tetrafluoroethylene propylene copolymer. Aflas® compounds have almost universal resistance to both acids and bases, steam, acid gases, crude oil and many types of corrosion inhibitors. Serviceability extends to 400°F for long-term exposure. With combined resistance to corrosion inhibitors and heat, Aflas® seals are able to resist the extremes of heat and pressure present in aggressive downhole oil well environments. Aflas® seals have very low rates of gas permeation and are highly resistant to explosive decompression, making them excellent choices for downhole packing elements.

Aflas® compounds have service temperatures from -10 to +400°F. Parco’s most popular Aflas® compound is 7117-80.

Fig. 8

Elastomer Selection Diagram



The six elastomers with superior oil resistance are found in the top half of the diagram. Elastomers used mainly in non-hydrocarbon applications are found in the bottom half of the diagram. Fluorocarbon and nitrile are repeated because they are also widely used with nonhydrocarbons.

⚠ This brochure is intended as a guideline and reference. Appropriate testing and validation by users having technical expertise is necessary for proper use of Parco products.

Parco
Parco, Inc., 1801 S. Archibald Ave., Ontario, California 91761
909-947-2200 Fax 909-923-0288 parcoinc.com